U.S. Army Research Institute
for the Behavioral and Social Sciences

Research Report 1801

Integrated Training and Performance Support for the Objective Force

May H. Throne and Billy L. Burnside
U.S. Army Research Institute

January 2003

U.S. Army Research Institute for the Behavioral and Social Sciences

A Directorate of the U.S. Total Army Personnel Command

ZITA M. SIMUTIS
Director

Technical review by

Mike Kelley, Training Development Cell, UAMBL
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REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) January 2003	2. REPORT TYPE Final	3. DATES COVERED (from. . . to) May 02 – Oct 02
4. TITLE AND SUBTITLE Integrated Training and Performance Support for the Objective Force		5a. CONTRACT OR GRANT NUMBER
		5b. PROGRAM ELEMENT NUMBER 0603007A
6. AUTHOR(S) May H. Throne and Billy L. Burnside (ARI)		5c. PROJECT NUMBER A792
		5d. TASK NUMBER 212
		5e. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: TAPC-ARI-IK 2423 Morande Street		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: TAPC-ARI-IK 5001 Eisenhower Avenue Alexandria, VA 22333-5600		10. MONITOR ACRONYM ARI
		11. MONITOR REPORT NUMBER Research Report 1801

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 words)*

The U.S. Army has begun transformation to an Objective Force operating within joint, interagency, and multinational environments. This transformation will require changes in training, with more of a reliance on embedded training and electronic performance support system (EPSS) capabilities, in order for units to be responsive, deployable, agile, versatile, lethal, survivable, and sustainable. This report reviews Objective Force training needs and applies an existing method for analyzing the appropriateness of alternative methods for meeting these needs. This initial analysis indicates that for the overall system of systems level, fully or appended embedded training is recommended. At the task level, embedded training is appropriate to varying degrees, depending on a number of considerations. Information on the performance of all tasks should be embedded, but practice of task performance with feedback should only be embedded where safe, reasonable, and cost-effective. This report also includes a brief summary of the embedded training and EPSS literature, leading to derivation of a set of usage considerations and design guidelines for developing effective embedded training and EPSS capabilities.

15. SUBJECT TERMS

Embedded training — Objective Force training
Electronic performance support systems — Training analysis

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	41	May H. Throne 502-624-2613

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January 2003

Army Project Number 2O363007A792	Personnel Performance and Training

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FOREWORD

The U.S. Army has initiated transformation to an Objective Force designed to be responsive, deployable, agile, versatile, lethal, survivable, and sustainable to meet the full spectrum of future missions. The training of soldiers, leaders, and units is key to the success of this transformation. Initial planning and acquisition documents indicate that the primary method for implementing Objective Force training will be embedded training and performance support. For many years the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has been involved in the development of embedded training concepts and methods, including the provision of extensive guidance on the implementation of embedded training. This guidance needs to be updated and adapted for application in the Objective Force environment.

This report provides an overview of Objective Force training capabilities needed and an application of a method previously developed by ARI to analyze the appropriateness of embedded training for meeting these needs. It also provides updated considerations and guidelines for the development and implementation of embedded training, broadly defined to include electronic performance support systems. The work supporting this report was performed as part of Work Package 212, "Unit Training Technologies for Future Forces." The relevant requirements document is a Memorandum for Record between the Deputy Director, Unit of Action Maneuver Battle Laboratory (UAMBL), U.S. Army Armor Center and Fort Knox and the Chief, ARI Armored Forces Research Unit at Fort Knox, entitled "Research and Development Related to Training Methods for Objective Force Units of Action Equipped with Future Combat Systems," dated 10 September 2002.

The results of this effort were presented to representatives of the UAMBL on 1 November and again on 6 December 2002. The analysis completed and guidelines developed should be highly useful to personnel in the UAMBL, the U.S. Army Training and Doctrine Command, and other agencies responsible for development and implementation of training for the Objective Force over the next several years.

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INTEGRATED TRAINING AND PERFORMANCE SUPPORT FOR THE OBJECTIVE FORCE

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army has begun transformation to an Objective Force operating within joint, interagency, and multinational environments. This transformation will require development of innovative training and performance support methods, in order for Objective Force soldiers, leaders, and units to be responsive, deployable, agile, versatile, lethal, survivable, and sustainable. While the Army recommends embedded training as the preferred approach for training future tasks, the appropriateness of that approach to provide Objective Force training needs to be analyzed. There is also a need to identify key issues and develop or update guidelines for the effective implementation of embedded training and performance support.

Procedure:

Previous work conducted by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) led to the development of a method for considering embedded training as a system alternative. The present report reviews Objective Force training needs and applies this existing method for analyzing the appropriateness of embedded training as well as alternative approaches for meeting these needs. The authors of this report worked through a series of decision flowcharts and worksheets for three phases of system of systems development. Methods of training considered included: fully embedded training, appended embedded training, umbilical embedded training, actual equipment training, and stand-alone device training.

Findings:

The analysis indicated that for the overall system of systems level, fully or appended embedded training is recommended. Umbilical embedded training is not recommended for meeting Objective Force training requirements. At the task level, embedded training is appropriate to varying degrees, depending on a number of considerations, such as the need to ensure that embedded training does not interfere with prime system operation, the availability of the system of systems for training, the requirement to train in operational or deployed environments, and the ability to present key visual and motion stimuli during embedded training. Information on how to perform all tasks should be embedded (i.e., embedded informing), but complete training including practice of task performance with feedback should only be embedded where safe, reasonable, and cost-effective. A brief summary of the embedded training and electronic performance support system (EPSS) literature is presented, leading to derivation of a set of usage considerations and design guidelines for developing effective embedded training and EPSS capabilities.

Utilization of Findings:

The results of this report can benefit personnel in the U.S. Army and Training Doctrine Command, the Unit of Action Maneuver Battle Laboratory, and other agencies involved in further definition and development of Objective Force training approaches. The considerations and guidelines presented will assist both training and system developers in the integration of embedded training and EPSS within the future system of systems operational environment.

INTEGRATED TRAINING AND PERFORMANCE SUPPORT FOR THE OBJECTIVE FORCE

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INTEGRATED TRAINING AND PERFORMANCE SUPPORT FOR THE OBJECTIVE FORCE

The U.S. Army has embarked upon an ambitious transformation to a lighter, more mobile Objective Force that can operate readily within joint, interagency, and multinational (JIM) environments. This force is being designed to possess seven essential characteristics or capabilities to provide strategic dominance across the full spectrum of operations, ranging from humanitarian assistance and disaster relief to major theater wars (Department of the Army [DA[1]], 2001c).

The Objective Force is designed to be *responsive* in terms of time, distance, and sustained momentum. It is to be rapidly *deployable*, with the capability to deploy a brigade-sized force (Unit of Action, the primary tactical element of the Objective Force) anywhere in the world within 96 hours, and a division (Unit of Employment) within 120 hours. It is designed to be *agile* enough to transition rapidly between various operations and missions, and to task organize on the move. It is to be *versatile* through being equipped and trained for all missions, with organizational structures requiring minimal adjustment for specific missions. It is to possess *lethal* combat power while providing *survivability* in the form of maximum protection for soldiers, on or off platforms. It is also to be highly *sustainable*, with units possessing the ability to sustain themselves for three days of high-tempo operations and up to seven days of low-end conflict.

Possession of the characteristics described above should enable Objective Force units to see first, understand first, act first, and finish decisively. The ability to acquire and process information rapidly to support knowledge-based operations will be critical. Objective Force units will be equipped with the Future Combat Systems (FCS), designed as a system of systems that is fully networked to ensure rapid and complete sharing of information. As the FCS will be fielded in several platform variants, the key to effective Objective Force operations will be networked linkages of platforms and other information sources (e.g., sensors, databases, knowledge repositories). To execute missions successfully, Objective Force soldiers and leaders must have near-continuous access to all relevant information in the form of a common operational picture[2] (COP), whether they are on or off an FCS platform. When dismounted, soldiers and leaders will need to access information through personal computers or other portable devices (U.S. Army Training and Doctrine Command [TRADOC], 2002a). These devices may include detachable access terminals that soldiers and leaders unplug and take with them when they dismount from a platform or transfer from one platform to another.

A key to Objective Force units achieving information dominance will be the command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) network (TRADOC, 2002a). This knowledge-based network (in conjunction with other networks) will enable Objective Force soldiers and leaders to receive, process, and transmit information rapidly to make and adjust decisions on the move. They will use the C4ISR network to accomplish almost all of their wide-ranging functions, including planning of operations,

[1] A list of all acronyms used in this report is included in Appendix A.
[2] Also referred to as common relevant operational picture (CROP).

controlling the placement and movement of manned and robotic sensing and firing elements, controlling the engagement of targets at extended ranges, and communicating and displaying information and orders. Also, they will likely use this same knowledge network to accomplish much of their training (Unit of Action Maneuver Battle Laboratory [UAMBL], 2002a).

In addition to achieving information dominance, another key to Objective Force units winning decisively will be the mastering of transitions (DA, 2001b, 2001c). Leaders will apply a train-alert-deploy-employ approach so that units are prepared to accomplish the full spectrum of operations within 96 hours. They will also need to prepare soldiers and units to transition rapidly between operations, such as going from offense to defense and back again, or from peacekeeping to warfighting and back again. Leaders will need to be able to recognize or anticipate when transitions are required, as well as to direct and monitor transitions through the C4ISR network.

The achievement of capabilities such as information dominance and the mastering of transitions depends heavily on the provision of effective training to Objective Force soldiers, leaders, and units. "The training system must be as responsive as the Objective Force" (TRADOC, 2002a, p. 64). The next section of this report summarizes training capabilities needed for the Objective Force, with a focus on collective training for Units of Action (UAs) and their subordinate elements. Following sections examine how these capabilities can be provided through embedded training as currently defined by the Army (DA, 1999), and then through a broad view of performance enabling, including not only embedded training but also electronic performance support systems (EPSS).

The goal of this effort is to show that enabling Objective Force soldiers, leaders, and units to meet future performance challenges will require comprehensive, integrated application of embedded training and EPSS technologies. The primary target audience for this report is designers and developers of Objective Force training systems. This report describes an initial analysis effort; the intent is for follow-on efforts to develop prototypical embedded training and EPSS applications.

General Objective Force Training Capabilities Needed

Specific training capabilities needed for the Objective Force have not been detailed and won't be for some time. Needed FCS capabilities are currently being defined during Concept and Technology Development, and the first UA is scheduled to be manned and equipped during Fiscal Year 2008. Current Army policy (DA, 1999) calls for training development and implementation needs to be identified during the analysis phase of the Systems Approach to Training (SAT)[3]. Using the SAT approach, training solutions to performance deficiencies (i.e., general training development requirements) are identified during needs analysis, based largely on available performance data and subject matter expert (SME) input. Overall missions and critical collective tasks are identified during mission analysis, and performance specifications and training requirements are then detailed during task and job analyses.

Several analysis efforts are underway to identify Objective Force training capabilities needed, including a joint effort of the UAMBL and the U.S. Army Research Institute for the

[3] The other SAT phases are: design, development, implementation, and evaluation.

Behavioral and Social Sciences (ARI) at Fort Knox to accomplish needs analysis. Such analysis is challenging when it is being accomplished for a completely new system of systems for which there are no identified performance deficiencies[4] and no SMEs. However, general training needs can be determined from vision statements and evolving acquisition documents for the FCS-equipped Objective Force. Plans (Department of Defense [DoD], 2002; TRADOC, 2002b) call for these training needs to be detailed further during simulation-based demonstrations and experiments over the next few years.

The key acquisition documents for identification of general Objective Force training needs are the Operational and Organizational (O&O) Plan for Maneuver Unit of Action (TRADOC, 2002c) and the Operational Requirements Document (ORD) for the FCS (UAMBL, 2002b). Both these documents exist in coordinating draft form and are continuing to be refined by the UAMBL. Key supporting documents include the Capstone System Training Plan (STRAP) for the FCS, which is Appendix F of the ORD; the Mission Needs Statement (MNS) for FCS (UAMBL, 2002a); the FCS Mission Area Analysis (Finken, Ingram, Lamb, Leath, & McLarney, 2002); the FCS Mission Needs Analysis, which is Appendix I of the ORD; the Objective Force Doctrine, Training, and Leader Development Plan (TRADOC, 2002b); and the Force Operating Capabilities for the Objective Force (TRADOC, 2002a). Examination of these and related documents leads to identification of several key training capabilities needed for the Objective Force.

Full Spectrum Operations

One of the most common training needs stated in acquisition documents is that the future force must be trained and ready to conduct missions across the full spectrum of operations in a joint environment. The Objective Force "will ensure its ability to dominate across the spectrum of military operations through well-trained and well-led formations" (DA, 2001c, p. 1). "Once in the area of operations, future combat forces must be versatile enough to meet varied mission demands across the spectrum..." (UAMBL, 2002a). This spectrum includes offensive, defensive, stability, and support operations in environments ranging from small-scale contingencies to major theater wars (DA, 2001b). Given the requirement to deploy within 96 hours, this means that elements of a UA must be trained and ready to perform a wide range of missions. Training support packages (TSPs) and other training materials must be produced and readily available to allow training for any type operation, or tools must be developed and included with TSPs to allow them to be tailored rapidly for any type operation (TRADOC, 2002a). To maintain readiness for performing a wide range of missions, UAs will need to spend a significant portion of their time training; "Training units for this capability requires more training resources and time" (DA, 2001c, p. 19). Gossman, Burnside, Flynn, Dannemiller, and Mauzy (2002) estimated that Objective Force units will need to spend as much as 80% of their time training to maintain required levels of readiness.

Joint, Interagency, and Multinational (JIM) Environments

The training challenges for Objective Force elements are further broadened by the need to train for performance in JIM environments. "More often than not, Army forces execute full-

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[4] Needs analysis usually starts with the identification of an actual or perceived performance deficiency (DA, 1999).

spectrum operations as part of a joint force" (DA, 2001a, p. 1-51). "Operations are becoming more distributed in time, space, and purpose and increasingly joint, multinational, and interagency in nature" (DA, 2001c, p. 3). This means that development and implementation of training programs must be coordinated across services, agencies, and nations, and that JIM elements must participate in or somehow be represented in execution of training exercises. If Army soldiers, leaders, and teams are to have access to JIM resources in future operations, they must have access to these resources in training. If these resources are not available for training, they must be simulated using tools such as intelligent agents and computer-generated forces.

Training Anywhere, Anytime

Descriptions of Objective Force training challenges frequently include the need for units to train anywhere, anytime. "They require relevant, on-demand training available anywhere, anytime..." (TRADOC, 2002c, p. 124). "Leaders and soldiers train...anywhere, anytime in all training domains – institution, home station, Combat Training Centers (CTCs), and deployed/employed" (UAMBL, 2002b, p. 60). This need is derived from the challenge to be ready to perform a wide variety of operations on short notice, as described above. The need to train anywhere, including while deploying or deployed, means that training must be deliverable in austere environments, using resources or media with which units are expected to deploy. As argued by Gossman et al. (2002), these resources include units' operational equipment and small portable devices. The need to train anytime implies that training support must be available continuously (not subject to scheduling constraints), and that the training support system must operate 24 hours a day seven days a week.

Training All Tasks

Gossman et al. (2002) further argued that Objective Force soldiers, leaders, and units will need training on all tasks (anything), anywhere, at anytime. Due to the wide range of performance requirements and degradation in performance without practice (forgetting) that can be expected to occur, UA elements will need the capability to practice (sustain) any and all required skills, tasks, or competencies anywhere, anytime. This means that all training must be developed for delivery in exportable or distributed forms, to the maximum extent possible. Units can thus deploy with their training support materials and/or reach through the C4ISR network or other information networks to central repositories in order to access training materials (or obtain updates to them).

Tailoring Training

The capability to train for a wide range of operations also indicates that Objective Force training must be tailorable or adaptable to users' needs, some of which will be unanticipated. Objective Force units "require relevant, on-demand training...tailored to the unit's operational requirements" (UAMBL, 2002b, p. 34). "All Army trainers, regardless of component or location, must have the capability to prepare, produce, and rapidly reconfigure individual soldier and unit performance-oriented, standards-based, and realistic multi-echelon training" (TRADOC, 2002a, p. 64). Since units may encounter unique situations with previously unknown training requirements, leaders will need the capability to modify available training materials or to develop

their own rapidly, using tools such as the Commanders' Integrated Training Tool for the Close Combat Tactical Trainer (Flynn et al., 2001). Units may accomplish this by reaching through knowledge networks to information repositories, SMEs, and training developers for assistance.

Team Training

Another significant aspect of Objective Force training capabilities needed is increased emphasis on the training of teams. "UA emphasizes training of teams vice individual platform capabilities..." (TRADOC, 2002c, p. 25). "The UA is organized around fighting teams..." (UAMBL, 2002b, p. 60). Thus, team as well as individual training must be available anywhere, anytime, and be deployable with the unit. Team training needs to be performance-oriented and experiential, building upon related individual training to support rapid teaming and mission preparation (TRADOC, 2002a). Team training also needs to include progressive combined arms exercises in which team members practice task performance together, starting with small teams and building up to larger units (Gossman et al., 2002). Also needed is "the capability to train when parts of the crew or combined arms team are unavailable" (UAMBL, 2002b, p. 46). There is thus a need for capabilities to realistically represent missing team members or other unavailable personnel (e.g., higher and adjacent elements) during the conduct of collective exercises. This will require computer-generated forces and intelligent agents that can realistically simulate missing team members or any combination of missing team members, as well as neutral and threat elements.

Training in Realistic Contexts

As with legacy and Stryker forces today, there will be a need for Objective Force soldiers, leaders, and units to train as they fight (DA, 2002). There will still be a need to "enable the unit to truly train, as it will fight" (TRADOC, 2002c, p. 125). This means that Objective Force training will be conducted with actual equipment in real environments, or with realistic simulations of equipment and environments. Since doctrine for Objective Force units is expected to evolve rapidly and be adaptable, it is anticipated that the means of conveying how to fight will be dynamic tactics, techniques, and procedures (TTPs), rather than more linear ways of providing doctrine, such as paper-based manuals. The training system must have direct links to rapidly evolving doctrine.

Performance Measurement and Feedback

Another fundamental training challenge that will not disappear is the need to measure performance and provide feedback (DA, 2002; UAMBL, 2002a). Training will still equate largely to providing practice opportunities with feedback supporting performance improvement. This feedback will usually be in the form of an after action review (AAR) for collective training, which may be conducted in distributed mode. "The training feedback mechanism must allow us to be able to determine in the construct of a collective training experience, does the unit demonstrate core competencies ..." (TRADOC, 2002c, p. 129). Objective Force training must include "an AAR capability that captures and assesses performance data" (UAMBL, 2002b, p. 45). This performance measurement and feedback capability should be as objective and automated as possible, given the expected decreasing availability of human observers in the

future. It should also be capable of adapting readily to evolving doctrine and performance standards, as well as adapting displays and other outputs to users' needs and preferences.

Interaction of Training Needs

The above discussion of Objective Force training capabilities needed shows that while some fundamental concepts will remain the same, much will change. In general the training system must deal with increasingly complex needs as units are expected to become more responsive to a wider range of missions in increasingly complex contexts. Soldiers and leaders must be trained not only to deal with complex dynamic missions, but also with rapid transitioning among them. "Mid grade and junior leaders must effectively recognize and solve problems in complex situations with political and informational dimensions" (TRADOC, 2002c, p. 23). "Objective Force leaders must be trained to do more and be more, earlier in their careers, and after less institutional and operational training time" (TRADOC, 2002a, p. 63). "Leaders will require greater risk tolerance, a different balance of abilities, as well as a better knowledge of joint processes much earlier in their careers" (UAMBL, 2002a, p. 5). The next section summarizes a general approach to meeting these complex needs.

Meeting Training Needs with Embedded Training

Acquisition documents for the FCS-equipped Objective Force are consistent in their view of the primary approach to addressing the challenging training needs for this force – embedded training. "The FCS training system must be fully integrated within the FCS system of systems architecture" (TRADOC, 2002c, p. 125). A key characteristic of the Objective Force training system is that it will be "embedded in FCS and command posts" (TRADOC, 2002c, p. 128). "Embedded training of all tasks (individual through brigade) is the preferred solution for meeting all of the UA training needs" (UAMBL, 2002b, p. 47).

Embedded training is not new to the Army. In fact, for many years Army policy has been that embedded training is the preferred alternative among other approaches for incorporating training sub-systems in the development of all materiel systems (DA, 1987). When that policy was established, embedded training was defined as "training that is provided by capabilities designed to be built into or added onto operational systems to enhance and maintain the skill proficiency necessary to operate and maintain that equipment end item" (DA, 1987, p. 1). The policy statement further noted that embedded training is not to impact system operation and may train individual tasks through force-level collective tasks. Since essentially the same definition is used in current Army training policy (DA, 1999), it will be used in this report for now. Issues dealing with the definition of embedded training and where it fits in the general context of performance enabling are discussed in more detail later in this report.

The renewed emphasis on embedded training in the vision for the Objective Force is due to the fact that this training approach seems to be the best way to meet many of the general training needs described previously. Embedded training certainly addresses the need to train anywhere, anytime, since it is integrated with operational systems and is thus deployable with them. Integration with operational systems also supports the need for units to train as they fight. With appropriate measurement techniques and tools designed into it, embedded training has the

potential to support at least semi-automated performance measurement and feedback. "The embedded training system will include...AAR production tools" (UAMBL, 2002b, p. 46). Embedded training also has the potential to provide training tailored to users' needs, again with appropriate adaptation techniques and software tools designed into it. The vision of embedded training for the Objective Force includes the capability to conduct team and multi-echelon collective exercises in a synthetic environment on operational networks, thus supporting team training. "The FCS embedded training system must provide virtual and constructive multi-echelon combined arms training capability for leaders, staffs, and units to build functional, combined arms teams" (UAMBL, 2002b, p. 46). As discussed previously, with the development and integration of intelligent agents, embedded training can include simulations of team members who are not physically present for training. Such agents could also represent elements external to the team/unit, including JIM entities.

The capability of embedded training to address the full spectrum of operations, or to provide training on all tasks, merits some discussion. Acquisition documents note that while embedded training is intended as the primary means for training the Objective Force, it is not the only means. "Nonetheless, some tasks are illogical or unsafe to train using embedded capabilities and must be trained using separate training aids, devices, simulators, and simulations (TADSS)" (UAMBL, 2002b, p. 48). For example, it seems illogical to embed training for basic physical skills such as cleaning weapons or preparing individual defensive positions (i.e., digging foxholes). As another example, it seems unsafe and probably not cost-effective to embed all drivers' training on actual vehicles; some initial TADSS-based drivers' training would seem advisable to reduce the occurrence of training accidents, especially when practicing driving under adverse conditions. It may also not be cost-effective or possible to have operational equipment available to meet initial training needs.

Gossman et al. (2002) argued that the key question is not what Objective Force tasks should be trained through embedded training, but rather how to embed the training of all tasks as completely and effectively as possible (thus providing capability for training all tasks in deployed environments to the maximum extent feasible). Looking further at the example of digging foxholes, the creation of instrumented virtual shovels for digging virtual dirt is not appropriate. But all available information on digging foxholes and ways to train and assess the digging of foxholes should be accessible from operational systems, to support training that may be required in all environments (including deployments) in which soldiers may need refresher or sustainment training. That is, information about the digging of foxholes should be embedded, while practice of digging with automated performance feedback should not (although virtual cues and prompts could perhaps be presented through "heads-up" displays or similar approaches in the future). However, the embedded training system should include the capability for manually entering observational data on soldiers' foxhole digging performance into their training records.

As will be discussed further in a later section of this report, it is important to note that Objective Force training will be embedded not just in individual weapons platforms, but throughout the operational information network(s). Soldiers and leaders can thus access training and information through any available means for accessing the network, including laptop computers and tablets, wearable computers, and personal digital assistants (PDAs). The form or

completeness of training is likely to vary for different access means or media; for example, it may not be possible to display all training situations or stimuli on a PDA that can be displayed on an operational weapons platform. But training should be designed for delivery to the fullest extent possible through all media that may be available to soldiers and leaders. This will maximize the portability of training and information.

It would appear that embedded training can be provided for Objective Force tasks to varying degrees, depending on characteristics of both the tasks and the access means. The training of some tasks can probably be embedded fully on operational platforms, with the full range of practice and feedback provided. It may be possible to embed only limited practice opportunities for other tasks on operational platforms, and such opportunities may be even more limited with other access means (separate computers, PDAs, etc.). It may be possible only to provide information relevant to task performance with no realistic practice of performance for other tasks (particularly when network access is gained through a device such as a PDA). This latter case might more appropriately be described as embedded *informing* rather than embedded training, since it does not include practice with performance feedback.

All available information on performance of all tasks should be accessible from Objective Force systems (including portable computers, PDAs, etc.), but practice with performance feedback should only be embedded to the extent safe, reasonable, and cost-effective. Systematic methods and criteria are needed for determining safety, reasonableness, and cost-effectiveness. Addressing issues of safety and cost-effectiveness seems fairly straightforward relative to addressing reasonableness. Perhaps this latter factor should be addressed in terms of the degree to which stimuli can be presented and responses can be recorded on operational platforms and other media.

Also, it may be that some Objective Force performance needs are not fully addressable through training, requiring some other form of support to enable performance. "The Objective Force must also have the capability to provide soldiers distributed technical assistance...while minimizing reliance on training" (TRADOC, 2002a, p. 66). The application of the embedded approach to training the Objective Force may thus not be as straightforward as it first seems. In the next section of this report, an existing method is applied to investigate further the appropriateness of embedded training for addressing various Objective Force performance capabilities needed. This application includes assessment of the method's capability for identifying when the embedding of practice with performance feedback is safe, reasonable, and cost-effective.

Application of Embedded Training Guide

In 1988, ARI published a set of ten volumes addressing methods for implementing embedded training (see Finley, Alderman, Peckham, & Strasel, 1988). The second of these volumes (Strasel, Dyer, Roth, Alderman, & Finley, 1988) discussed factors that should be considered when evaluating embedded training as a system alternative. Witmer and Knerr (1996) have addressed use of these factors and others in the form of a systematic guide and decision charts for making embedded training decisions early in system acquisition. The purpose of the guide is to help the user determine, early in the acquisition process, what training should

be embedded and what training should be provided by other means. This guide, developed in conjunction with Simulation, Training, and Instrumentation Command, is the only reference that the present authors found that provides a systematic process for making embedded training decisions. Application of the guide to the ongoing acquisition of a system of systems supporting the Objective Force seems timely and highly appropriate for verifying that embedded training should be the primary means for training that force. Such application may help answer questions raised above on development and implementation of embedded training for the Objective Force, as well as identify additional key issues to be considered in addressing safety, reasonableness, and cost-effectiveness. It may also identify updates and expansions needed in the guide itself for application in a system of systems environment. The remainder of this section describes an application of the guide completed in the early stages of the FCS acquisition process.

The embedded training guide requires the user (the guide was written for training developers as the primary users) to work through a series of decision flowcharts and worksheets organized into phases, with initiation of each phase triggered by the level of information available on the system being acquired. Phase I is conducted early in acquisition, during what is now called Concept and Technology Development (CTD). This phase is generally conducted at a broad level of detail, with analyses addressing the overall system (system of systems in this case) or major missions the system is designed to support. Phase II is conducted in close succession to Phase I, at the mission or function level of detail. Phase III is generally conducted during what is now called System Design and Demonstration (SDD), at the function or task level of detail. Phase IV is basically repeated iterations of Phase III as more detailed information becomes available. A cost analysis is usually completed in conjunction with Phases III and IV to consider costs associated with the training alternatives recommended.

The training alternatives considered in the guide include three types of embedded training. Fully embedded training is completely integrated into the prime system. Appended embedded training can be completely installed on or attached to the prime system when needed and removed when it is not. Umbilical embedded training is similar to appended, but requires physical connection to computers or other external components (an option that may not be tenable for training during deployments). Other training alternatives from the guide that are of interest here include training which can only be accomplished on actual equipment, and training on stand-alone simulators or devices that are not part of the prime system and do not depend on prime system operation to train. Such devices include computer-based versions of operational software as well as high-fidelity simulations of operational equipment.

The authors of the present report served as analysts for completing the application of the embedded training guide to the FCS, based on draft acquisition documents and other information available. Since acquisition of the FCS was in CTD at the time of the application, the analysts decided to work through decision charts for Phases I and II and for Phase III as much as possible, but not to attempt to work through Phase IV decision charts or cost worksheets. In regards to the level of detail of the analysis, the analysts decided to work through decision charts at the overall system of systems level first. While general missions to be accomplished by Objective Force units had been identified at the time of the analysis (TRADOC, 2002c), it did not seem likely that working through decision charts for selected missions would lead to unique conclusions for the applicability of embedded training. To reach such conclusions and to address key embedded

training issues (e.g., when embedded training is appropriate and how it may need to be supplemented), it seemed necessary to complete analyses at the function or task level. Since identification of Objective Force functions and tasks had not been completed at the time of the analysis, the analysts decided to conduct the analyses for a small sample of potential Objective Force tasks. These tasks were generated by the analysts to represent a range of Objective Force performance requirements that might have different implications for embedded training. In addition to the overall system of systems analysis, tasks generated for analysis were:

- control placement and movement of subordinate elements.
- conduct tactical movement.
- drive a manned FCS platform.
- perform maintenance on an FCS platform.
- prepare an individual defensive position (dig a foxhole).

The first three tasks above were generated to represent different levels of the movement function: commanding and controlling movement of others (probably through observing icons on a screen from a fixed position), moving as part of a formation of manned (and perhaps unmanned) platforms, and driving an individual platform. The fourth task was included to add consideration of a combat service support or logistical function. The final task was included to add consideration of a task for which embedded training seemed illogical (see previous discussion of the foxhole digging example).

The primary product of each phase of the guide is a matrix (an updated matrix in phases after the first) indicating the activities (system, mission, function, or task) that should be considered for training by the specified training alternatives. For the sake of simplicity, the results of the three phases of analysis for all five selected tasks and the system of systems level are consolidated here, and only the training alternatives selected in the FCS analyses are included (other alternatives in the guide, such as classrooms and appended devices, were not recommended or excluded in the FCS analyses). Each alternative is described in the simplified matrix as either recommended as a training approach for unit or institutional training, or excluded from further consideration. The simplified matrix resulting from the FCS analyses is shown in Table 1.

Completing the analyses leading to the results displayed in Table 1 required working through decision charts and answering approximately 70 questions each for most of the tasks considered (digging foxholes required fewer answers, approximately 30). Thus, the details of each analysis are not presented here. Rather, the general results are discussed, along with key issues that influenced the results. Lessons learned and recommendations for the guide methodology itself are then described.

The first conclusion apparent from Table 1 is that at the overall system of systems level, the analysis confirms the appropriateness of embedded training for Objective Force unit training. Fully and appended forms of embedded training are recommended for unit training. The umbilical form of embedded training is excluded for all activities analyzed. This exclusion resulted from the analysts' decision that the training system is required to be mobile (i.e., it must

move with the prime system), and that the training system is to be used in assembly areas during go-to-war situations (and other future operational situations). Deployability considerations thus eliminate umbilical embedded training as an alternative for the Objective Force. Note that this exclusion of umbilical embedded training does not exclude the possibility of downloading training software and updates into Objective Force systems, perhaps requiring an antenna or other means. In the opinion of the present authors, such downloading capability should be an inherent part of all Objective Force systems, rather than being umbilical to them.

Table 1

Matrix of Future Combat Systems Training Alternatives

System or Task	Actual Equipment Training	Embedded Training			Stand-Alone Device
		Fully	Appended	Umbilical	
Overall system of systems		Recommended (for unit training)	Recommended (for unit training)	Excluded	Recommended (for institutional training)
Control placement and movement of subordinate elements		Recommended (for unit training)	Recommended (for unit training)	Excluded	Recommended (for institutional training)
Conduct tactical movement		Recommended (for unit training)	Recommended (for unit training)	Excluded	Recommended (for institutional training)
Drive a manned FCS platform		Excluded	Excluded	Excluded	Recommended
Perform maintenance on an FCS platform		Recommended (for unit training)	Recommended (for unit training)	Excluded	Recommended (for institutional training)
Prepare an individual defensive position (dig a foxhole)	Recommended	Excluded	Excluded	Excluded	Excluded

In the case of institutional training, stand-alone devices are the recommended training approach. This is based on the analysts' decision that sufficient numbers of prime systems will not be available at institutions to support embedded training applications. The acquisition and fielding schedule for the FCS is ambitious, and it seems unlikely that sufficient FCS platforms will be fielded to training institutions to support embedded training. Plans thus need to be

initiated for the acquisition of stand-alone devices to support institutional training. However, high-fidelity simulators of FCS platforms may not be required in large numbers. Since success of Objective Force operations will depend heavily on information sharing through operational networks, it will be more important to provide computer stations with access to simulated or real networks. These stations should look and operate like stations on actual FCS platforms, but they will not have to be mounted on simulated platforms (i.e., they do not have to be "just like" stations on FCS platforms). It is also important to note that the roles of institutions may change as training becomes increasingly distributed in the future. Institutions may become distribution centers and repositories of information rather than sites where extensive training is conducted with students in residence. In the opinion of the present authors, only initial entry training may be conducted at centralized locations at some point in the future. This will further reduce the need for FCS platforms or high-fidelity simulations of them at training institutions; only a few may be needed for familiarization purposes.

Since the analysis was conducted at a general level, the results for both controlling and conducting tactical movement are the same as the system of systems results, based on the analysts' decisions discussed above. The same is true for performing maintenance. While this indicates that training the control and conduct of movement and the performance of maintenance can be accomplished in the same general way, further analysis at the task and subtask levels would be needed to determine exactly how embedded training should be developed for these tasks.

The analysis for driving an FCS platform produced different results – the exclusion of all forms of embedded training and the recommendation of a stand-alone device for training. These results can be traced to the analysts' decisions that key motion stimuli may be required for drivers' training and that these stimuli cannot be simulated or otherwise provided on FCS platforms. It does not seem safe or cost-effective to embed motion simulation into FCS platforms, nor does it seem safe or cost-effective to conduct initial drivers' training through driving of actual platforms. Stand-alone devices will thus continue to be needed for drivers' training, at least for initial training and for training under adverse or unsafe conditions. Sustainment training may be accomplished on actual equipment. It seems likely that (under normal circumstances) soldiers will not be allowed to drive an FCS platform until they have achieved a specified level of proficiency on a stand-alone driving simulator. Achievement of proficiency levels will be checked by commanders; at some point in the future it may be checked by the system itself. That is, soldiers may swipe a card or provide some other sort of identifying information (including training and performance history) before the engine of a platform will start for them.

Finally, the results for digging foxholes are as expected – the recommendation for actual equipment training and the exclusion of all other alternatives. The primary decisions influencing the recommendation for actual equipment training were that there is no policy or stated preference favoring embedded training in this case; this training need has historically been met by use of actual equipment, and there is no need to use simulation to reduce accidents. Some tasks are best trained as they traditionally have been, and this is one of them. However, as noted previously, information about digging foxholes and other tasks for which embedded practice is

not reasonable should still be accessible on Objective Force networks (i.e., embedded informing).

Another set of results from this application of the embedded training decision guide is lessons learned about the methodology of the guide itself. The application was fairly straightforward and seemed to lead to viable results. However, it did require considerable effort to reach general conclusions. As noted previously, in most cases the guide requires analysts to make decisions or answer questions as many as 70 times. Some of the questions are not entirely clear and require interpretation (e.g., questions on whether the manpower, personnel, and training impacts of embedded training can be met). Some of the questions are difficult and may not be answerable early in system acquisition (e.g., questions on system availability for institutional training). It should be noted that the guide was not designed for use by research and development personnel, but rather by training developers who might have more ready access to information needed to answer such questions. The results for each activity analyzed are generally recommendation of one training alternative and perhaps exclusion of others. In the FCS application, the methodology led to identification of the best general (or macro) combination of training methods across the activities analyzed, but it did not lead to identification of specific (or micro) mixes of training methods within each activity, or of the degree or specific way in which embedded training should be applied for each activity. Reaching such conclusions would require extensive analysis at the level of task elements, and such detailed information on Objective Force tasks may not be available for some time.

Given the results above, application of the embedded training decision guide is useful at least at the general system and function levels, but it is resource-intensive to complete at task or lower levels. In addition, much of the detailed information on tasks to be performed and plans for system implementation may not be available when a completely new system of systems is being acquired. Some of the concepts and terms in the guide may need to be updated for the Objective Force environment. For example, as noted previously, institutions may become centers from which training is distributed rather than centers where extensive training is conducted in residence. For these reasons, it is recommended that the guide be updated and automated support be developed for its implementation prior to extensive application of it in analyzing alternative means to meet Objective Force training needs. Extensive, detailed analysis is needed to support embedded training decisions for the Objective Force, and the guide provides a systematic means for doing this. Also, the guide identifies many key issues and considerations for the implementation of embedded training.

The embedded training decision guide points out important general considerations, such as the following: since fully embedded training is part of the system itself, the design of embedded training must proceed concurrently with design of the prime system; and, embedded training can provide initial acquisition as well as sustainment training, if performance measurement, feedback, and record keeping are included. The guide also identifies ten consideration factors that were used in developing decision charts: policy; training environment; prime system availability for training; training content; technical feasibility; reliability, availability, and maintainability; manpower, personnel, and training support requirements; training-specific interface requirements; safety; and, effectiveness relative to alternatives. The application of the guide to the FCS acquisition led to identification of several more specific

factors or issues in the decision charts that were key in the decisions made. These are: (a) possible interference of embedded training with prime system operation; (b) wear and tear on prime system components while accomplishing embedded training (possibly leading to need to ruggedize components); (c) availability of the prime system for training while deploying or at the institution; (d) requirement to train in operational or deployed environments; and (e) ability to present key visual and motion stimuli during embedded training. Most if not all of these factors or considerations seem to relate to the issues of safety, reasonableness, and cost-effectiveness discussed earlier. It thus appears that an updated embedded training decision guide can provide criteria for addressing these issues systematically, given that criteria or factors considered in the guide are defined as clearly as possible and automated support is developed to ease guide implementation.

Application of the embedded training decision guide has confirmed the appropriateness of embedded training as the primary method for training selected tasks in Objective Force units, and has identified several key factors that need to be considered. But many questions remain to be answered about exactly how specific tasks (or more likely groups of tasks, since tasks are seldom trained in isolation) will be trained through embedded means to the maximum extent safe, reasonable, and cost-effective. To what extent can practice opportunities and feedback be embedded for each task? What training methods are needed to supplement embedded training, particularly when the prime system is not available? What performance support may be needed in addition to training? As discussed earlier, it would seem that a broad perspective is needed in order to enable Objective Force soldiers, leaders, and units to meet wide-ranging performance challenges. Considerations and guidelines for when and how to enable Objective Force performance should thus not be drawn from just the embedded training decision guide or any other single source, but from a broad review of relevant literature. These considerations and guidelines should be applicable in design and development of embedded training for specific tasks or activities identified through detailed analysis as being appropriate for such training, as well as for design and development of alternative performance enabling means for tasks or activities that are not fully appropriate for embedded training. To support identification of such considerations and guidelines, the next major section of this report provides a review of the relevant literature from a broad perspective, including not only embedded training but also electronic performance support systems (EPSS).

Enabling Performance for the Objective Force

As previously discussed, in order to be prepared to respond rapidly across the full spectrum of operations, Objective Force units will need to be able to train anywhere anytime, using all media or training delivery options available to them. While these units will maintain high training readiness on their priority missions (train-alert-deploy-employ), it is expected that they often will need to conduct final mission-specific training or rehearsal just prior to or during deployment. This means that training must be increasingly delivered at a distance to dispersed sites. It also means that training must be deliverable on equipment or media that a unit deploys with; this includes training embedded within the FCS and other operational equipment,[5] and training delivered on small transportable devices. Soldiers and leaders of the future need

[5] As noted previously, the platform may support an embedded training capability, but the actual training may reside on the network rather than the platform.

integrated training and performance support that is continuously available, up-to-date, and readily adaptable to dynamic needs. "Embedding training and performance support systems into the Objective Force's concept, organizational and system designs will provide ...flexibility and further enhance readiness" (TRADOC, 2002a, p. 65).

In deployed environments it may not be feasible for soldiers and leaders to access and participate in training to meet all their performance requirements. Sometimes, all soldiers or leaders will need is a prompt on how to complete the next task step, not a complete training session. Other times, soldiers or leaders may need more information in order to reach a decision, or they may want to be sure they have the most recent data available before making a decision. Therefore, something more than just embedded training is needed to enable units to perform optimally. A combination of embedded training and electronic performance support is required to ensure that soldiers, leaders, and units will be able to accomplish their tasks efficiently and effectively. Electronic performance support may take many forms, as noted in acquisition documents. These include automated cognitive decision and planning aids (UAMBL, 2002b), communication and service support aids (TRADOC, 2002a), collaborative, distributed problem solving aids, and tools for terrain and automated pattern analysis (TRADOC, 2002c). Electronic performance support should "decrease task complexity and execution times to improve performance while minimizing sensory, cognitive, and physical demands on the soldier" (TRADOC, 2002c, p. 149).

As systems become more complex, the operator becomes responsible for more functions or subsystems that are used on an intermittent basis (McGraw, 1994), and the training and performance support requirements increase. The capability is needed to assist "...multi-skilled soldiers to perform mission essential tasks that are inherently difficult, complex and/or multi-step, are performed infrequently, or have not been previously performed" (TRADOC, 2002a, p. 66). Before identifying the training and performance support needs, there must be a general understanding of what each term means. The problem is that there is much confusion and disagreement over what the terms "training" and "performance support" mean and how they are different. For example, a recent DoD publication describes training as including education and job-performance aids as well as training (DoD, 2002). Some researchers in the performance support arena have been arguing that training is no longer as important as performance (e.g., Gery, 1995b; Gustafson, 2000), while others consider training as a part of performance support (e.g., Bastiaens, 1999; Varnadoe & Barron, 1994). Still other researchers attempt to make distinctions between training and performance support (e.g., Gery, 1991; Rosenberg, 1995) while some believe that these two areas contain a great deal of overlap (e.g., Bramer & Senbetta, 1993; Sherry & Wilson, 1996; Wilson, 1998).

Redefining the boundaries of terms such as training and performance support is a recurring trend in the literature reviewed. Regardless of how these terms are defined, they are both methods of enabling performance. This means that both methods have the same goal; they only differ in specificity and immediacy of enabling accomplishment of performance to standard. Training provides the user with required knowledge along with practice and feedback in applying that knowledge in order to reach task proficiency. Training is used to support initial acquisition of skill performance as well as for sustaining or refreshing such performance. While

training can be accomplished through various methods (e.g., simulation, computer-based, classroom instruction), the method of primary interest here is embedded training.

Performance support, on the other hand, presents the appropriate information, at the appropriate time (i.e., during task performance) and level of specificity, using techniques appropriate to the user's ability and needs (McGraw, 1994). The method of performance support reviewed in this report is EPSS. Other methods of performance support include paper-based job and decision aids and advice from expert performers. The Army's goal for the Objective Force is to embed training and performance support as much as possible into operational networks, although Army policy does not distinguish between embedded training and EPSS (Tyler et al., 2002).

The intent of this report is not to focus on the differences between embedded training and EPSS, but rather to show that although there are differences, the considerations and guidelines for when and how to implement them can be integrated. Both embedded training and EPSS will be needed to enable Objective Force soldiers, leaders, and units to meet their challenging performance requirements. These performance enablers must be developed and implemented in an integrated and complementary fashion. For example, the availability of EPSS does not eliminate the need for training; training is still needed to enable timely performance without extensive reliance on EPSS (one measure of proficiency may be the ability to perform a task without use of EPSS). Also, EPSS is still needed by highly trained and skilled performers, to address problems such as forgetting and task interference. As background for integration of embedded training and EPSS, a short summary of the literature in each of these fields is provided in the next two sections. Extractions from these literature reviews are then summarized in the subsequent two sections in the form of listings of considerations for when to use embedded training and EPSS, and general guidelines for how to design embedded training and EPSS once the usage decision has been made.

Embedded Training Review

A primary need for the Objective Force is to "...develop a transformed training capability that provides accurate, timely, relevant, and affordable training and mission rehearsal in support of specific operational needs" (DoD, 2002, p. 6). In order to meet this need, capabilities such as embedded training (including embedded simulations supporting collective exercises) and integrated simulators and training devices will become priorities in the acquisition process (DoD). Although the similar Army (DA, 1987) and TRADOC (DA, 1999) definitions of embedded training were used earlier in this report, neither definition fully conveys the underlying potential of embedded training. For example, both definitions focus on operators and maintainers as the only users; leaders and functional users supporting leaders should be included. Additionally, both definitions focus on enhancing and maintaining skill proficiency, while ignoring initial skill development. The DA/TRADOC definition needs to be expanded to include more than just operators and maintainers. The present authors have thus refined the definition of embedded training as follows: training provided by capabilities built into or added onto operational systems to provide, enhance, and maintain the skills, knowledge, and abilities necessary to enable task performance.

It is important to keep in mind that when the Army develops embedded training for FCS, this refers to an embedded training capability. The training may not necessarily be fully embedded in each FCS platform. In fact, it most likely will not be. Instead, it will reside on operational networks and each platform will have the capability to access and download information and software as needed. Training will thus be embedded fully in the network; it is not umbilical to the network since network connections (wired or wireless) are an inherent part of the system of systems. For the user, differentiation of the location of software and information is not important, since it will be transparent. However, from a systems design perspective, the systems will operate much more efficiently and effectively, since everything will be available from a central location or hub. This is similar to many peoples' computers at work. Generally, the computers are connected to a central server, which is where much of the software and information resides. This saves hard drive space and memory on users' computers, allowing them to accomplish tasks faster. All of this is transparent to users, yet allows them to perform their tasks more efficiently. Access to the Internet provides a similar analogy. Desktop computers provide access to the Internet and software or information needed is downloaded for a particular application. However, the Internet is not embedded in desks or desktop computers; it is embedded (or resides) in a network that is accessible through computer terminals.

There are four categories or levels of training at which embedded training can be employed (TRADOC, 1996). The most basic level is the individual level, where the goal is to use embedded training to train and sustain individual skills. Next is the crew/team level, where the objective is to build on individual skills as well as train combat ready crews and teams. Third is the functional level. Here the objective is to train commanders, staffs, crews, and teams in each area they will utilize within their operational roles. Finally, the objective of the force level/combined arms and battle staff or command group level is to train combat ready commanders and battle staffs collectively in their operational roles. These levels not only recognize the need to train from individual to collective, but also that all can be accomplished through an embedded training capability.

A few years ago, the Naval Research Laboratory developed a prototype embedded trainer for new operators of the Navy Tactical Command System Afloat (McGroder, 1995). The first requirement considered when building the trainer was that although the training would be embedded, it should still be clearly distinct from the operational mode. Not only should the two modes be distinct, but going from one to the other should also be "...quick and straightforward, especially in crisis or demanding situations" (p. 4). Secondly, the training should be clear-cut and the graphical user interface should be user-friendly, simple, and concise. The graphical user interface of the training and the operational system should also be the same or similar. Changing button locations or switching the order of appearance of screens between the two modes will lead to negative transfer of training. Finally, the training should be designed to allow for nonlinear execution of training sessions. Users should be allowed to branch off in any direction they need in order to train on the task. McGroder stated that it is important to keep in mind not only how the system will be used, but also how users will be trained.

The most recent and comprehensive review of embedded training in the military was conducted by Morrison and Orlansky (1997). They not only identified examples of its use in earlier years, but also summarized 56 different embedded training systems used by the military,

including historical systems no longer in use and proposed systems that were not yet implemented. For each system, they provided the military branch, system name, parent system, a functional description, an assessment, and positive and negative features. Some of their findings include: the decision to embed training must be evaluated on a case-by-case basis; an advantage of embedded training is that it allows the unit to train with the same operational equipment that it takes to war; a disadvantage of embedded training is that it may reduce the capability of operational equipment by adding weight and increasing wear and maintenance; and finally, although embedded training is considered effective and acceptable by users, few valid and reliable data exist on its cost and effectiveness.

A list of the benefits and risks associated with embedded training is also presented in the Functional/Operational Description for Military Embedded Training Architecture (Army Training Support Center [ATSC], 2001). Some of the benefits include: high fidelity, greater training availability, immediate feedback, standardization of training, just-in-time training and mission rehearsal, and capability for initial, refresher, and sustainment training. Some of the risks include: high level of time and money associated with development, more wear and tear on the operational equipment, may not be available during mobilization if personnel and equipment are separated, and students may not take full advantage of exploratory opportunities.

High fidelity can be achieved through embedded training, because the training system can be designed to look just like the operational system. In fact, from the user's perspective the training system may be the same as the operational system, except for some clear indication that the system is in training rather than operational mode. Although this may not always be the best solution, embedded training does provide an almost unlimited amount of fidelity. It is up to the training developers to decide how much is enough without wasting resources. An embedded training capability will also allow users to train more often if the operational system is available. If it is not available, other training opportunities exist. Training should also be available through other electronic devices (e.g., laptops, electronic tablets, PDAs) to make training more accessible. The training accessed with such devices may be lower fidelity than training accessed from operational platforms, but it seems likely that many functional- and force-level training needs can be met via access with portable devices. As Objective Force training needs are identified in greater detail, further analysis will be needed to determine which needs must be met through embedded training accessed from platforms versus other means.

With embedded training, users may be able to receive immediate feedback on performance. This is essential in training, so users can quickly understand how their performance affects task completion. While embedded training can lead to more standardized training, it still allows room for personalization. Training can be adapted to meet a user's needs while still covering the same material as another user may receive. Finally, embedded training can provide the capability for users to train anywhere at anytime on any task they need, either individually or collectively.

While the risks mentioned by ATSC (2001) are worth noting, they may not be too severe. For example, although it may be true that development of embedded training does take more time and money than traditional methods, it is usually a one-time cost. After its development, only updates are needed as systems are revised, and these updates can and should be

accomplished in conjunction with updates to operational systems. In extended cost analyses, embedded training may come out costing less than most other methods. Although there will be more wear and tear on the operational equipment, this may not be as significant in the future as it has been in the past. As Army systems become increasingly digitized and human-machine interactions are increasingly accomplished through software tools (e.g., voice recognition) rather than hardware (e.g., switches and buttons), there will be fewer moving parts to wear out. While it is true that the systems may not be available while being deployed, users will still have access to the network through their laptops or other hand-held devices. Since the training is actually in operational networks rather than in the platforms, there will be no loss of training time due to deployment. Finally, some students may not take full advantage of exploratory opportunities, no matter what the method of training. While these students cannot be forced to make use of the available opportunities, future research needs to determine how best to persuade students that these opportunities are to their advantage.

Volume 7 in the original ARI embedded training series (Purifoy, Ditzian, & Finley, 1989) deals with test and evaluation of embedded training. Purifoy et al. stated that in order to achieve fully embedded training, the training hardware and software must be a transparent part of the operational system. This can only happen if the training is developed concurrently with the development of the system of systems. If training is being developed concurrently, it must be tested and evaluated before the final product is completed, because once a system is fully developed, it may be too late to go back and make changes without drastically affecting it. Therefore, continuous evaluation of the training is critical. Purifoy et al. listed six activities as ways to make sure the embedded training will not only be effective, but also effectively integrated into a system:

- oversee to assure training system developers are working with operational system designers.
- oversee to assure analyses are done to make sure the operational system and embedded training system are configured properly.
- evaluate to confirm the embedded training design will function as needed to deliver the training.
- evaluate to demonstrate that the prime system hardware and software can accommodate the embedded training.
- test to assure the embedded training will teach when and where it is needed.
- test and evaluate to confirm the embedded training successfully evolves with changes in the operational system.

Electronic Performance Support Systems Review

The term EPSS was first coined by Gloria Gery. She defined it as a computer-based system that includes access to information, guidance, advice, assistance, training, and tools to enable performance with minimum support from other people (Gery, 1991). Gery's definition incorporates training into the EPSS concept. The opinion of the present authors is that embedded training will most likely provide the initial training piece, and the support included in EPSS will

be focused more toward diagnostic, remedial, and sustainment training for specific immediate skill requirements. Nevertheless, there will be much overlap between the two. For example, the EPSS may use screens from the initial training as prompts or aids and it may even send the user back to a portion of the embedded training if remedial training is deemed necessary (and the user is not in the middle of performing a critical operational task). No matter whether initial training is part of EPSS or what constitutes an EPSS, the concept has essentially remained the same – it is a custom-built interactive guidance, learning and information support capability that is integrated into a normal working environment (Lawton, 1999).

There are three basic types of EPSS: intrinsic, extrinsic, and external (Gery, 1995a), which are similar in concept to the three types of embedded training presented earlier. Intrinsic support is integrated with the system to the point that it is seen as the operational software itself. Extrinsic support is integrated with the operational system, but is not part of the primary display and is either invoked by the user or is presented to the user and can be turned on or off. An example of extrinsic performance support is electronic help. Help, which may include procedural advice, general hints, or reasoning support, should be available at any time from the system, and it can be either user-initiated or system-initiated. (A system-initiated advisor may be more difficult because the system has to constantly monitor user performance to determine when support is appropriate.)

External support is not integrated with the work context and may or may not be computer-based. An example of external performance support is a paper-based job-aid (e.g., a checklist). The goal of a designer should be to integrate as much as 80% of performance support as intrinsic support (Gery, 1995a). It is the opinion of the present authors that, for the Objective Force, intrinsic and extrinsic EPSS along with fully embedded training should together provide at least 80% of the performance enabling required.

It is important to keep in mind that often, when EPSS is designed properly, users may not even be aware that it is there. If a program walks the user through accomplishing a task, that is a form of intrinsic EPSS. For example, TurboTax® is a software program designed to walk the user through filling out both federal and state tax forms. TurboTax® works by first providing the user with a blank W-2 form to be filled out. Each box on the blank form is numbered to match the paper W-2s so there are no questions about which numbers go where. Afterwards, the program asks the user questions to compute salary and deductions. In most cases, the user does not have to guess at what counts as a deduction and what does not. TurboTax®'s direct questioning technique leaves little room for doubt. If the user is still unsure about a particular item, help is always available on demand. From the user's perspective, the on-demand help is obviously EPSS, but so is the rest. Although the questions may not seem like EPSS since they are such an intrinsic part of the software, anyone who has sat down with the paper versions of the tax forms understands their importance. The questions get the user through the form completion process with less effort on the user's part than filling out the forms by hand, while ensuring the maximum deductions possible are taken.

On the other hand, not all assistance makes for good EPSS. A website called http://www.pcd-innovations.com, which is referred to as EPSS Central, contains numerous examples of positive EPSS features, as well as negative ones. One familiar example of an EPSS

is "Microsoft® Office's detested paperclip" (Manes, 2000, ¶ 2). The paperclip's goal is to serve as an intelligent agent to help the user accomplish certain tasks. For example, if the user starts to type a document formatted like a letter, the paperclip makes a noise, becomes animated, and says, "It looks like you are typing a letter. Would you like help?" The user has the choice of receiving help or working on without help. More often than not, the help is not accepted and the paperclip may be distracting and in the way. Users have to interrupt what they are doing to click on the "No" button to continue without assistance. The user can hide the assistant, but only temporarily. The next time he or she accesses the help file, the paperclip comes back (Isys Information Architects Inc., 1999). In more recent versions of Microsoft® Office, if the user hides the assistant numerous times, a dialog box will come up saying, "You've hidden me several times now. Would you like to permanently turn me off or just hide me again?" As before, users must stop their tasks to click on a response button; this may interfere with current task performance.

A majority of EPSS design information comes from websites. Unfortunately, most websites are difficult to navigate and usability studies have found that when people are asked to accomplish simple tasks at websites, the success rate is less than 50% (Nielsen & Norman, 2000). When shopping on the Internet, users first determine usability of a site and then purchase something. If users can't locate a product, they can't buy it and they will probably never go back to that site again. The same principle is true of EPSS for the FCS. If the EPSS is annoying or gets in the way, users will be less likely to utilize it. If they cannot easily find what they are looking for, the next time they will not be inclined to use it.

While the Army's focus is on embedded training, most of the work in the EPSS arena comes from the Navy. For example, Cichelli (2000) reviewed an EPSS designed for network administrators on a ship platform to support network operations and prevent system failures. This EPSS supports troubleshooting, analytical decision-making, just-in-time learning for network concepts and procedures, and user customization. It also contains policies and guidance. The goal of the EPSS is to help sailors quickly achieve high levels of consistent performance regardless of their prior knowledge and skills. The EPSS components include a troubleshooting section; a pass-down log, so operators can pass critical items to the next watch; a job responsibilities section, which includes an outline of job responsibilities, examples of job tasks, and access to examples of properly completed forms and reports; and a reach capability which links to the Navy Learning Network and shipboard resources, including self-paced courses. Although Cichelli does not provide any data to support the effectiveness of this EPSS, she concludes that the system provides an appropriate level of guidance for novice network administrators while providing flexibility for expert administrators.

Another EPSS, developed during the Adaptive Diagnostics and Personalized Technical Support (ADAPTS) project, was designed for the Naval Air Warfare Center (Brusilovsky & Cooper, 1999). The goal of the ADAPTS project was to provide an adaptive EPSS for maintenance technicians. This was accomplished by adjusting the diagnostic strategy based on the technician and what he or she was doing. Based on the technician's responses, the sequence of setups, tests, and repair/replace procedures adapt accordingly. In order to adapt diagnostic strategy, the system maintains a dynamic user model for each technician. Based on the technician's past work with the task, the diagnostic system develops a custom-tailored, step-by-

step task list. The detail provided in the list is based on the technician's expertise. For example, a novice technician receives an expanded outline with subtasks, while an expert technician receives the collapsed task list, which can be expanded if necessary. Color-coded icons identify completed, current, and remaining task steps. Explanations also differ based on technician ability. For example, an expert might receive a reminder, while a novice would receive a complete description.

One of the examples of an effective EPSS presented on the EPSS Central website is the maintainer's EPSS (MEPSS™), which is being designed for Navy aviation maintainers (Hall, 2001). The MEPSS™ incorporates troubleshooting help, a parts database, maintenance records, technical manuals, and training into one system. Whereas the previous environment was completely paper-based, the MEPSS™ provides maintainers with easy access to everything they need in a portable, digital format. The interface is designed to be used on devices with small screens (i.e., laptops) and to allow for a touch screen capability. When provided with a login name, password, and the job number for the problem needing troubleshooting, the MEPSS™ will generate information geared toward the user and the current problem. Although the MEPSS™ is still under development, initial usability tests indicate that even maintainers with no computer experience are able to navigate through the system without assistance and successfully complete their tasks.

As seen in the previous examples, when designing an EPSS, the system must allow for a high degree of user control, be flexible enough for a novice as well as an expert user, provide a seamless interface, and allow multiple ways to access the same information (Milheim, 1997). Users should be allowed to receive support in the manner most appropriate to their learning styles. Some users may prefer to see a video demonstration of the task being performed, others may want step-by-step instructions, while others will only need a hint or reminder. Novices may need step-by-step instructions while experts may only require a hint. The EPSS should differentiate among users and provide the support best suited to each individual. If intrinsic EPSS is incorporated into the operational system, this will provide the most seamless interface. Even if intrinsic EPSS is not feasible for some tasks, extrinsic can be designed to appear seamless. This can only happen if EPSS is integrated early in the systems design process. Finally, users should be allowed to access information in multiple ways. For example, they may click on a map icon to see the latest reconnaissance video of an area or they may scroll through a list of current reconnaissance videos and come up with the same video. The U.S. Coast Guard's Performance Technology Center, which is developing and implementing cost-effective EPSS applications, uses two standards by which to measure EPSS success (Arnold & Brandt, 2000). The first is the amount of time it takes the average Coast Guard user to perform a task using EPSS versus manuals, job aids, or other support tools. The second measure is the quality of task performance. A successful EPSS enables the user to not only identify and perform all task steps in proper order, but also to an expert level.

It is important to keep in mind that EPSS may not be appropriate for all tasks. For example, as noted earlier, actual equipment training is the preferred method for training the digging of foxholes. According to Brown (1996), conventional training may be more appropriate when:

- resources are not available for EPSS development.
- lead time is not sufficient for EPSS development.
- simple drill or practice is enough.

Although Brown only refers to EPSS when providing these considerations, they seem to apply to embedded training as well. In the end, as McGroder (1995) states, the real power of embedded training "...comes not from the components themselves, or even how flashy the graphics may be, but from how the training coordinators and training development teams use the advanced features available to them to create cohesive, informative, simple to use, and understandable instructions to train..." (p. 4).

Usage Considerations

Although many researchers discuss use of embedded training or EPSS, there is no comprehensive listing of when these methods are appropriate. Since there are numerous similarities between these two types of performance enablers in the opinion of the present authors, a consolidated list of considerations, gathered from various sources (Brown, 1996; Chase, 1998; Ladd, 1993; Tracey, 1998) has been developed. Most of the considerations gathered come from the EPSS community, but they also apply to embedded training. Embedded training and EPSS are most useful when:

- computers will be used regularly in task performance.
- a majority of the work is mental rather than physical.
- personnel turnover is high.
- current training is insufficient.
- training costs need to be cut.
- job performance needs improvement.
- supporting information is difficult to access.
- system users are geographically dispersed.
- on-the-job training is important.
- the user will be engaging in complex tasks.
- the users are not closely supervised.
- mistakes in task performance are costly.
- the organization is downsizing.
- users have diverse learning styles.
- users need access to experts to perform their jobs.
- information and technology explosions have occurred.
- expectations for performance are high.

Most of these conditions appear to apply to UAs, again confirming the appropriateness of embedded training for the Objective Force. For example, most tasks will be accomplished with the use of computers, and much of the work will be mental, especially for command groups. When turnover occurs, it will be essential to bring new unit members up to speed quickly and integrate them seamlessly. With UAs covering larger areas with fewer people, they will almost always be geographically dispersed and there will be limited close supervision. The majority of tasks will be complex, which means on-the-job or just-in-time training will be important. Mistakes in task performance could be costly, and in some circumstances, could even lead to death. In any large organization, users will have differing learning styles and there is an expectation of superior performance for everyone. Finally, information and technology explosions have already occurred, and more are likely before Objective Force fielding. Overall, embedding training and EPSS in Objective Force networks should greatly assist UAs in achieving higher levels of performance.

Design Guidelines

Once the decision has been made to use embedded training and EPSS, training developers will need a set of guidelines for building appropriate performance enablers. These guidelines should supplement decision guidelines developed by Witmer and Knerr (1996); it is important to keep in mind that, as Witmer and Knerr state, "...the [embedded training] guidelines must be a living document" (p. v). The present authors have compiled a list of general design guidelines gathered from Volume 10 of the ARI embedded training series (Carroll, Roth, Evans, & Ditzian, 1988) and the STRAP (UAMBL, 2002b). These guidelines (presented below) are based on capabilities that should exist for successful embedded training and EPSS. Embedded training and EPSS capabilities should:

- be fully compatible with the prime system.
- be as fully integrated with the prime system as possible.
- not endanger personnel, equipment, or data through incorrect operation.
- not compromise security of the system or its data.
- have minimal impact on the prime system's reliability, availability, and maintainability.
- not lead to negative transfer in the operational mode.
- enable combined arms (and JIM) proficiency.
- leverage UA network(s) architecture.
- allow on-demand access (reach) to doctrine and TSP repositories.
- provide collaborative wargaming tools, supporting mission planning and rehearsals, while deploying or deployed.
- provide required tactical engagement simulation for the full range of weapons, including electronic warfare.
- provide Combat Training Center (CTC)-like instrumentation: data capture, management, and analysis, along with rapid feedback.

As stated in the first bullet, the embedded training capability needs to be compatible with Objective Force networks and platforms. This means that the embedded training can in no way interfere with the operational capability of the system. Users must be able to easily switch between the two modes and must instantly be able to recognize which mode they are in at any given time. This may be accomplished through something as simple as color coding, where the menu bars or border around the training mode screens are a different color than the operational mode screens. In addition, the commander needs to have an override capability so he can quickly switch anyone who is in training mode to operational mode if the need arises. If the two modes are not fully compatible, units will be less likely to use the embedded training capability. Similarly, the EPSS must also be compatible. If support pops up at inappropriate times or in inappropriate screen locations, it will do more harm than good. If the EPSS gets in the way of operational performance, it will be turned off or ignored. Anyone who has ever used Microsoft® products and has dealt with the paperclip (previously discussed) can understand this. It may be necessary to adjust the level of automated EPSS to the operational situation. For example, in the middle of an operation EPSS might be designed to intrude only when inappropriate performance may lead to injury to personnel or damage to systems.

Not only must the training and performance support be fully compatible, they must also be fully integrated within the system of systems. The embedded training and EPSS must look to users as if they are an integral part of the system. They must also be closely linked to each other. For example, using screens from the embedded training in the EPSS as refresher training or having the EPSS send someone back to the embedded training for remediation will convince users that all parts of the system are working together to achieve optimum performance. Such an approach also leads to efficiency through reuse of materials.

The third bullet relates to ensuring the safety of personnel, operational equipment, and data stored on the system. As mentioned previously, users must be able to unequivocally identify whether they are in training or operational mode. If a user believes he is in training mode when in fact he is in operational mode, it could have grave consequences, both for personnel and equipment. Since the training data will be the same as those used in operational mode, security as well as safety measures need to be in place to make sure the data are not compromised.

Training must be designed so that soldiers will be able to train on the actual platform as well as on laptops or smaller hand-held devices. This means that system and data security will be a major concern, especially with use of wireless networks. Not only does the platform have to be secure, the network also needs built-in security measures to ensure users have secure access to all they need without compromise.

The training and performance support must also have very little impact on the platform's reliability, availability, and maintainability. If the embedded training and EPSS are fully integrated into the system, then the reliability and maintainability should be no different from that of the operational system. If continuous evaluation is being conducted throughout the design and development process, any deficiencies in these areas should become apparent in the early stages. Availability should not be greatly affected since platforms are not the only place where training can occur. For example, if a platform is under maintenance, the user can bring up

the same or highly similar screens on his laptop and train from there. Since the embedded training resides in the operational networks, it should be accessible from any nodes in those networks, not just the platforms.

It is crucial that training not have a negative effect on operations. However, this does not necessarily mean that training has to be built just like the real system. Sometimes this strategy is not only inefficient but also ineffective. For example, in the operational world, complications may occur that would be overwhelming to include in training, especially initial training. Radio communications (or even the C4ISR network) may be down at times in the operational world, but soldiers receiving initial training probably should not participate in scenarios where this occurs. They must first master using their systems in a perfect world before moving on to degraded mode training. The Army has maintained a crawl-walk-run strategy toward training and plans to continue this approach in the future (DA, 2002). Training and performance support must be designed in a way so that users can positively transfer what they learn over to the actual system.

The embedded training capability must support collective as well as individual training, including team or unit exercises in a synthetic environment with individuals participating in the training or being represented by intelligent agents. This capability must enable combined arms training at anytime, along with JIM training. All personnel having access to operational networks through their platforms or other means from any location (including distant locations) could be involved in collective training exercises. Therefore, combined arms (and JIM) training should be easier to accomplish than it has been in the past. However, achieving this potential requires rapid and significant advances in the technologies of intelligent agents and computer-generated forces. This should be a high priority area for future research and development.

As is apparent from the previously discussed bullets, the operational network architecture will be heavily leveraged. The embedded training and EPSS will pull from the network(s) the relevant information that users will need to accomplish their tasks. Since all training and support materials will reside and be kept up-to-date in the network(s), they can be accessed from anywhere at anytime.

Not only will the embedded training and EPSS capabilities allow on-demand access to doctrine and TSP libraries, they will also allow users to add to or revise information contained in TSPs. In the future, paper-based TSPs may not exist as they do today. All available training support materials will exist in a large database or network of databases, in the form of reusable objects or elements. Electronic files of materials needed by each training participant will be retrieved, organized, and distributed with the help of intelligent agents. More than likely, no user will ever need to see the whole TSP. Intelligent tools or agents will use available elements to create new TSPs as needed. Thus someday a practically infinite set of TSPs (or more accurately portions of TSPs needed by individuals) will be available. Such electronic packaging of materials for use cases might more appropriately be called training applications rather than TSPs.

Intelligent agents and wargaming tools supporting embedded training, EPSS, and collective exercises in a synthetic environment embedded in operational networks should also support mission planning and rehearsal. For example, collective exercises could be conducted

rapidly on the network with no live participants in order to wargame alternative courses of action. Once an optimal course of action is determined (using the same embedded performance measurement tools used to support training feedback), execution of it could be practiced or rehearsed repeatedly by various mixes of participants, just as training exercises are conducted. It is very important that embedded training and mission planning/rehearsal be developed as aspects of the same system with maximum reuse of elements, just as embedded training and EPSS are aspects of the same performance enabling system. The embedded training and mission planning/rehearsal system could also be used to develop TTPs for previously unencountered tactical situations or for incorporating previously unavailable capabilities. That is, TTPs could be wargamed and refined in simulation on operational networks (using tailorable computer-generated forces) prior to implementation in real situations. This will provide required "...real-time distributed, multi-echelon collaborative planning support tools to achieve knowledge-based course(s) of action development, wargaming, and decision support" (TRADOC, 2002a).

Embedded training and EPSS must support all tactical engagement simulation requirements, but these requirements may not be the same as those addressed today through live tactical simulations (e.g., Multiple Integrated Laser Engagement System) and virtual gunnery trainers (e.g., Conduct of Fire Trainer). More than line-of-sight gunnery must be addressed; since Objective Force units will attempt to engage targets at extended ranges, training the conduct of beyond-line-of-sight and non-line-of-sight engagements must be supported. Employment of alternative means of attacking or countering the threat, such as electronic warfare, must also be addressed. In the Objective Force it may be rare for tactical engagements to be conducted by a human laying a reticle on a target and tracking it. When this is necessary, it may be conducted largely by robots or automated systems under the control of humans. The presentation of virtual targets through optical sights or out-the–window views may thus not be a major requirement for Objective Force training. The bigger requirement may be training the control of the distribution of fires and other effects through indirect views of the environment.

Finally, it will be essential to provide data capture, management, and analysis tools to support provision of training feedback as well as archiving of performance data. For training feedback, these tools must be easy to access as well as adaptive and easy to use. Commanders and supporting personnel should be able to choose which analyses they want and in what output format (e.g., picture, graph). If they want to do a different analysis from what is available, they should have the option to build their own and add it to the repository. Not only should users receive rapid feedback, but collective feedback should also be available in time for team or unit reviews. Again, commanders should have the capability to build their own measures for presentation in an AAR-type setting. For archiving purposes, these tools should provide leaders and units with a way of easily archiving performance data (reporting back) to support development of TTPs and lessons learned.

Conclusions

As the Army transforms to the lighter, more mobile Objective Force operating within JIM environments, training and performance support anytime, anywhere will become increasingly important. This should be accomplished through the integrated application of embedded training and EPSS. All tasks should be trained through either embedded training or EPSS to the extent

safe, reasonable, and cost-effective; techniques for determining the degree to which tasks meet these three criteria should be a focus of research as Objective Force systems are designed and developed. Using Witmer and Knerr's (1996) embedded training decision guide is one approach to determine when to use embedded training. As the authors discovered when using it, although it is useful at a general level, it is a time-consuming process. Updating the guide for the Objective Force environment and developing automated support for its implementation may be an important step toward determining the safety, reasonableness, and cost-effectiveness of implementing embedded training and EPSS for each task. While the training of some tasks may not be embedded fully (thus requiring stand-alone devices), all available information on performing them should be embedded in (or accessible from) Objective Force systems.

Several usage considerations and design guidelines were presented to support development of future performance enabling capabilities. To date, there is no comprehensive list of guidelines that embedded training and EPSS developers can follow once the decision has been made to use embedded training and EPSS. Therefore, an attempt was made to provide an initial set of guidelines that, if followed, would lead to a more functional embedded training and EPSS capability. As the FCS is further developed, this initial list needs to be revised and expanded to keep up with current capabilities.

Most importantly, embedded training and EPSS development must advance concurrently with the system of systems development. If it does not, it will become almost impossible to integrate the two at a later date and the embedded training capability will not be leveraged to the fullest. Many EPSS functions depend upon early integration. For example, an intelligent agent or personalized help may not be as effective if it is an add-on to a system rather than integrated with system development. Additionally, if the embedded training and EPSS do not appear to users to be integral with the systems, they most probably will not be utilized since they will appear to be a separate program or function. Finally, users may be less likely to trust the system recommendations and advice offered by the embedded training and EPSS capabilities if they are not integrated. If the capabilities are not fully embedded, users may not be willing to accept that they are providing valuable support and guidance. In that case, users will fall back to more traditional (and cumbersome) methods of support, such as seeking guidance from someone who knows how to perform the task.

Training, especially embedded training, is not something that will emerge on its own as system development moves forward. Training and system developers need to work together as integrated process teams in order to produce a training capability that will allow users to engage in successful task performance anywhere at anytime. Early consideration of embedded training and EPSS is just as important as other system development considerations, such as materiel and architecture.

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APPENDIX A

List of Acronyms

AAR	after action review
ADAPTS	Adaptive Diagnostics and Personalized Technical Support
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ATSC	Army Training Support Center
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
COP	common operational picture
CROP	common relevant operational picture
CTC	Combat Training Centers
CTD	Concept and Technology Development
DA	Department of the Army
DoD	Department of Defense
EPSS	electronic performance support system
FCS	Future Combat Systems
JIM	joint, interagency, and multinational
MNS	Mission Needs Statement
O&O	Operational and Organizational
ORD	Operational Requirements Document
PDAs	personal digital assistants
SAT	Systems Approach to Training
SDD	System Design and Demonstration
SME	subject matter expert
STRAP	System Training Plan
TADSS	training aids, devices, simulators, and simulations
TRADOC	U.S. Army Training and Doctrine Command
TSPs	training support packages
TTPs	tactics, techniques, and procedures
UA	Unit of Action
UAMBL	Unit of Action Maneuver Battle Laboratory